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# Sipunculid Burrows in Coral Reefs: Evidence for Chemical and Mechanical Excavation[1]

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ABSTRACT: The crystalline structure of sipunculid burrow linings from dead coral as studied with the scanning electron microscope indicates the presence of etching similar to that produced by treatment of unmodified coral surfaces with acid, and with EDTA. Initial biochemical activity appears to weaken intercrystalline bonds, permitting detachment of crystals by mechanical abrasion and subsequent deposition of their fragments in spaces between corallite walls.

Rock-boring sipunculid worms form burrows in dead coral heads or in the dead parts of living coral and are an important factor in the bioerosion of many reef areas. They attack predominantly calcareous substrata over a wide range of textures and hardnesses (Rice 1969) and attain densities as great as 700/m² in Hawaiian reef limestone (Kohn and Rice 1971). As summarized by Rice (1969), both mechanical and chemical mechanisms of boring have been advocated. The presence of such abrasive structures as hooks, spines, and papillae on the introvert and body wall lend support to a theory of mechanical boring, while the presence of glands in the epidermis and the restriction in habitat to a predominantly calcareous substratum argue in favor of a chemical mechanism. No specific chemical agent has been identified in relation to sipunculid boring activity. A study of burrow linings in thin sections of rock has shown "an alteration of constituent grains at the edge of the burrow and also an accumulation of comminuted skeletal debris in pockets in the walls of the burrow," and this has been interpreted as possible evidence for mechanical and chemical activity (Rice and MacIntyre 1972). In the present study, we have examined by scanning electron microscopy (SEM) the fine structure of burrow linings of the sipunculid *Themiste lageniformis* taken from dead coral and have found further evidence of both chemical and mechanical modification of the substratum.

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## MATERIALS AND METHODS

Coral burrows were rinsed with distilled water, oven-dried at 65° C, coated with gold-palladium, and observed with a Cambridge S4-10B Stereoscan. Burrows were also rinsed, oven-dried, and artificially etched with chemicals at the following concentrations: 10-percent and 99.7-percent acetic acid, 1.48-percent and 37-percent hydrochloric acid, and 1-percent and 10-percent ethylenedinitrilotetraacetic acid disodium salt (EDTA). For treatment with dilute acids and dilute EDTA, several drops were added to a piece of coral until a reaction was observed. For treatment with concentrated acids, a fine wire was dipped in the acid and used as a probe to touch very small areas of the surface. For concentrated EDTA treatment, the coral was etched for 45 seconds in a 10-percent solution. In all cases coral samples were rinsed thoroughly in distilled water, oven-dried, and vacuum-coated for observation with the SEM.

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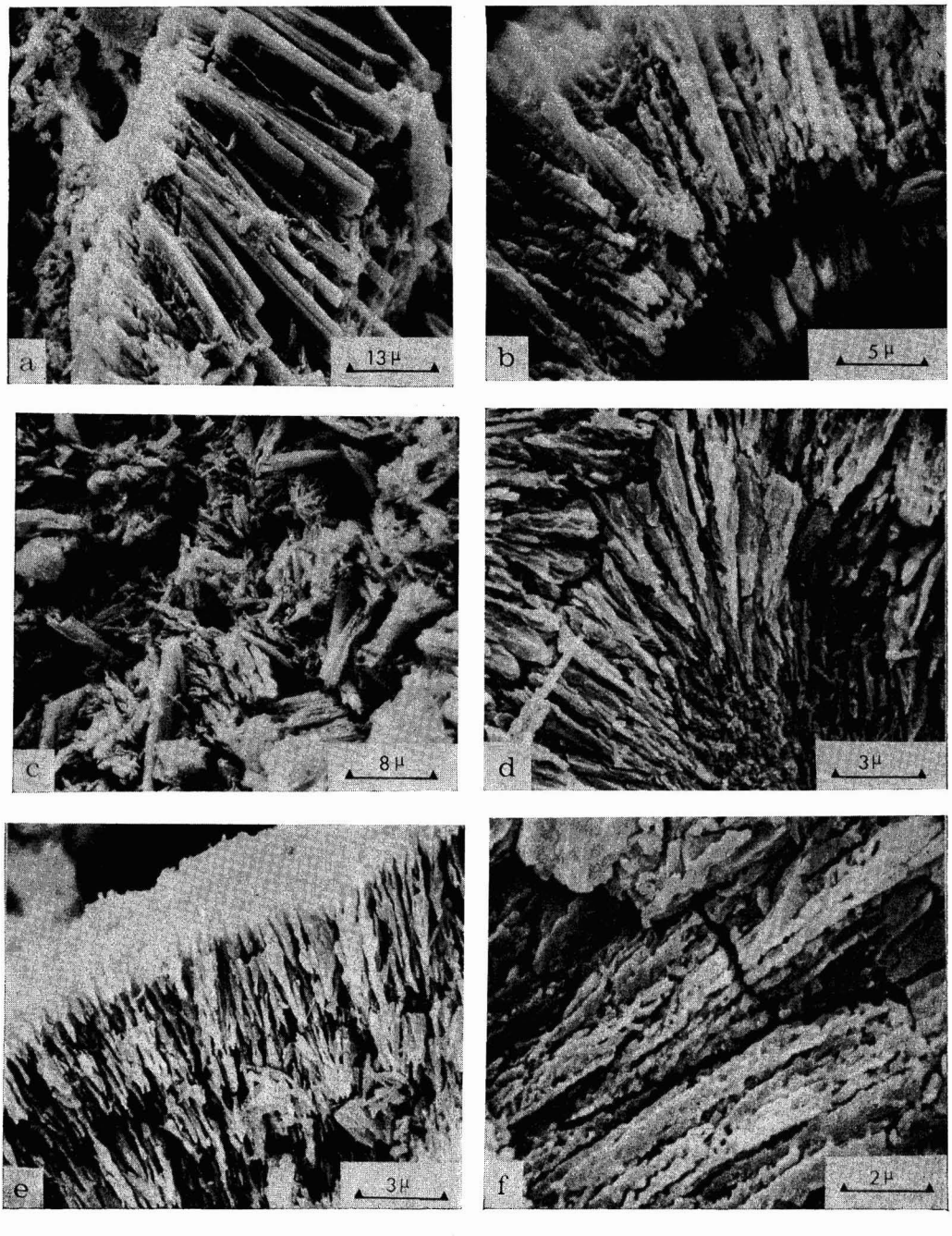


FIG. 1. *a*, Normal coral skeletal crystals at the outer edge of a sipunculid burrow. The left-hand margin of the crystal layer marks the edge of the burrow lining and shows evidence of chemical erosion by the sipunculid; *b*, corallite wall crystals in the surface of a burrow lining showing chemical etching by the sipunculid; *c*, etched, broken, crystal fragments deposited between corallite walls in a burrow lining; *d*, etching pattern of normal coral crystals treated with 1.48-percent hydrochloric acid; *e*, etching pattern of normal coral crystals treated with 10-percent acetic acid; *f*, etching pattern of normal coral crystals treated with 10-percent EDTA.

## RESULTS

In comparison with normal coral skeletal crystals (Fig. 1*a*) those within corallite walls lining the burrow are etched, pitted, and eroded to varying degrees with a corresponding reduction in diameter due to progressive chemical dissolution (Fig. 1*b*). Crystals in the burrow lining that are located in spaces between corallite walls (Fig. 1*c*) fail to show the usual parallel orientation and appear to be totally disrupted in relation to one another, fractured to some extent, broken completely away from the substratum, and deposited in disoriented masses within the spaces. In addition, each of these crystals shows the irregular, pitted outline similar to those located in corallite walls at the burrow surface.

Observations of burrows in cross section show that crystals in the burrow linings differ markedly from those in the underlying corallum. The ends of crystals forming the burrow surface are pitted, etched, and eroded; while the portions below the burrow surface are smooth and regular in outline. The alteration appears to occur only at the interface between burrow lining and sipunculid epidermis and does not extend into the underlying corallum. Although algal burrows were observed in areas adjacent to sipunculid burrow linings, no evidence of such burrowing organisms (algae, sponges, fungi) was observed in the surface of sipunculid burrows.

In order to verify the types of alterations produced by chemical solution of coral crystal, we etched pieces of coral artificially with dilute and concentrated solutions of hydrochloric acid, acetic acid, and EDTA and examined them with the SEM. Etching patterns similar to those observed in sipunculid burrow linings were observed in the experimentally etched coral (Fig. 1*d, e, f*).

## DISCUSSION AND CONCLUSIONS

The evidence suggests that the sipunculid may possibly form its burrow biochemically either by use of a chelating agent or by rapidly lowering the *p*H of the solution between its epidermis and the coral skeleton, irritating effects being neutralized by the ensuing reaction. The presence of etched crystals *in situ* in exposed corallite walls in addition to aggregates of etched, disrupted crystals filling spaces between corallite walls along burrow linings indicates that the sipunculid may initially use chemical etching to destroy the bonding between individual corallite wall crystals; it then removes them by abrasion with its epidermal papillae and subsequently deposits them in spaces between corallite walls. Sipunculid burrows, therefore, appear to be excavated by a combination of mechanical and chemical processes.

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